

Parameters of Chemical Composition of *Phaseolus coccineus* L. Pods Grown in Protected Areas

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Runner beans are an important source of carbohydrates, fibers, vitamins and minerals that play an important part in the cardiovascular and gastrointestinal tract physiology. The aim of the study was the identification of crop specificities of four varieties of Phaseolus coccineus L. homologated in the Great Britain: Lady Di, Desiree, Polestar and White Apollo, which are less cultivated in Romania, although during the study they proved a remarkable crop production. Another objective of the study was the determination of some chemical composition parameters of the pods harvested from protected areas, in order to highlight the particularities that could determine the expansion of their cultivation in our country.

Keywords: *Phaseolus coccineus* L., chemical composition, crop yield, macro- and micronutrients, antioxidant properties

Legumes are one of the most important sources of protein, carbohydrates and dietary fibers. *Phaseolus* genus includes a variety of species, among which *Phaseolus vulgaris* (common beans) are the most widely cultivated in the world, and *Phaseolus coccineus* (runner beans) are cultivated predominantly in America and Europe, for seeds and ornamental purposes [1].

Although less cultivated and studied in Romania, *Phaseolus coccineus* L. are of particular interest on the international level [2]. Some of their aspects that were relatively recently studied were: chemical composition, organoleptic properties, physico-chemical characteristics [1], the emulsifying and foaming properties of proteins [3], the effect of oligosaccharides on protein foaming properties [4], oligosaccharides degradation capacity of α -galactosidase [5], the anti-proliferative and anti-oxidative effect of dimeric lectin [6], the antineoplastic potential and the specific antifungal action of sialic-lectin [7], the influence of hydrothermal treatment on digestibility [8], the influence of methyl jasmonate on the response to oxidative stress in copper-treated *P. coccineus* L. [9]. Those studies have been carried out on dry seeds of *P. coccineus*, as those were the most researched vegetal material compared to the pods or the green seeds of the plant [10-12].

Our work focused on identifying crop specificities in protected areas of four varieties of *P. coccineus* L. homologated in the UK (Lady Di, Desiree, Polestar and White Apollo) and on the determination of chemical composition parameters of their pods, in order to highlight the particularities that could determine the expansion of their cultivation in our country.

Experimental part

The research was initiated at the Teaching Reservation of the Ion Ionescu de la Brad University of Agricultural Sciences and Veterinary Medicine of Iasi by preparing a protected area, covered with a polyethylene film. The soil conditions were: cambic chernozem (black earth) with medium fertility, 3% organic substance and pH = 6.5. The

temperature during the vegetation period was 18°C and the relative humidity of the air was 64% [13]. The biological material consisted of four varieties of bean originated from the UK: Lady Di, Polestar, Desiree and White Apollo as there are no homologated varieties in Romania. The experimental protocol consisted of organizing the area in subdivided parcels with three replicates, each replicate comprising of six hills with two seeds each.

The direct planting of seeds was done on May 20th 2014, in hills placed at 30, 40 or 50 cm in 100 cm equidistant rows. The seedling planting was done on June 3rd 2014 in hills. Seedlings were seeded on May 20th 2014 in 9x9x10 cm pots on a peat substrate. The seedling thus obtained was planted in 100 cm equidistant rows, at distances of 30, 40 and 50 cm in between hills of two plants each. The support system consisted of a plastic net with a mesh size of 15x15cm and a width of 1.7 m, placed 30 cm above the ground. Another net was stretched for support, approximately 2 meters above the ground, immediately after planting the seedlings.

During the vegetation period, specific procedures for root and foliar fertilization were done, that included the use of growth stimulators, as well as phytosanitary treatments [14-16]. The pollination of the flowers was achieved using a bumblebee hive because *Phaseolus coccineus* L. is alogamous [17].

The determination of the chemical composition parameters was carried out at the Faculty of Pharmacy of Grigore T. Popa University of Medicine and Pharmacy of Iasi on samples of two types of pods: pods of maximum length and of ¾ of maximum length. Each parameter was determined three times on three replicates.

The determination of moisture, ash, organic nitrogen, proteins, glucose, vitamin C, calcium, magnesium, iron and copper were performed according to AOAC International methods [18-26].

Results and discussions

Runner beans Lady Di produces red flowers that form

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30cm long tender pods. The pods are completely without strings, delicious and especially succulent, due to the very slow development of purple seeds with black markings.

Desiree produces a very abundant crop of large beans that grows well in normal and drought conditions. That variety produces white flowers and wide and stringless pods up to 30cm long with few white seeds. The pods are glossy, aromatic and savory.

Polestar is a British variety created for high production and reliability, which led it to become the favorite of the growers. The succulent, aromatic, stringless pods grow in bunches and reach up to 25cm in length. It is precocious in producing red flowers and yields high throughout the season.

White Apollo produces straight, smooth and stringless pods up to 37 cm long, with an excellent flavor. This variety produces prolific crops over a long harvest period, with high yields throughout the summer.

All of these features (fig. 1) were based on the observations recorded during the experiment and they were consistent to literature data [1].

Early production of green beans varied from 840 kg/ha (White Apollo seeds x33.000 hills/ha) to 8250 kg/ha (Lady Di seeds x20.000 hills/ha). For total production, the production ranged between 5934 kg/ha (White Apollo seedling x33.000 hills/ha) and 23633 kg/ha (Polestar seeds x20.000 hills/ha). The average value of early production was 4123 kg/ha and the total production was 13830 kg/ha. All production results for both the early and the full ones are shown in table 1.

The humidity of fresh pods was above 90% in all investigated samples and it varied for the $\frac{3}{4}$ Lmax pods in between 91.13% (White Apollo variety) and 93.68%

(Polestar variety), and for the Lmax pods in between 91.31% (Desiree variety) and 93.00% (Polestar variety). In the literature there is data on the moisture content only for seeds of Nata and Karo varieties of *Phaseolus coccineus* L., for which the recorded values were 11.1 ± 0.0 , and $12.0 \pm 0.0\%$ respectively [8].

The determination of mineral substances as ash obtained through calcination provided the following results: in the case of the $\frac{3}{4}$ Lmax pods the value was 0.60% for the Lady Di and Desiree while for the variety White Apollo 0.76%, 0.63% for Polestar and 0.73% for White Apollo, the pods at maximum length. Other authors obtained values of $5.24 \pm 0.24\%$ and $4.29 \pm 0.26\%$ for the fresh seeds of *Phaseolus coccineus* L. of the Nata and Karo varieties [8].

Determination of organic nitrogen using the Kjeldahl method led to a range of values for $\frac{3}{4}$ Lmax pods in between 1.03% for Lady Di and 2.43% for Desiree and for the Lmax pods in between 1.59% for White Apollo and 3.01% for Desiree.

The percentage of proteins in the composition of the pods was calculated based on organic nitrogen concentrations by multiplying it by 6.25 [8]. The values obtained were between 6.43% (Lady Di variety) and 15.18% (Desiree variety) for fresh $\frac{3}{4}$ Lmax green beans, and between 9.93% (White Apollo variety) and 18.81% (Desiree variety) for pods at maximum length.

The glucose concentration in the samples harvested at $\frac{3}{4}$ of the maximum length was 2.79 g% for Lady Di, 1.51 g% for Desiree, 4.01 g% for Polestar and 2.13 g% for White Apollo variety. The values of 1.92 g%, 2.59 g%, 2.15 g% and 2.08 g% respectively were determined for the pods harvested at their maximum length.

Calcium concentration in fresh pods samples harvested



Fig. 1. The aspect of the four varieties of *Phaseolus coccineus* L.

Table 1
PRODUCTION RESULTS OF *Phaseolus coccineus* L. GROWN IN PROTECTED AREAS

Variety	Biological material	Early yield (kg/ha)				Total yield (kg/ha)			
		33.000 (hills/ha)	25.000 (hills/ha)	20.000 (hills/ha)	Mean	33.000 (hills/ha)	25.000 (hills/ha)	20.000 (hills/ha)	Mean
Lady Di	seeds	4104	5708	6483	5432	14043	14381	17964	15463
	seedlings	7264	6240	8250	7251	13382	13575	20113	15690
	mean	5684	5974	7367	6342	13713	13978	19039	15576
Desiree	seeds	965	1246	2809	1673	6591	7533	11272	8465
	seedlings	1651	3684	3468	2934	9816	15778	17115	14236
	mean	1308	2465	3139	2304	8204	11656	14194	11351
Polestar	seeds	3167	3844	7125	4712	16694	17763	20726	18394
	seedlings	5514	8177	6683	6791	13537	23357	23633	20176
	mean	4341	6011	6904	5752	15116	20560	22180	19285
White Apollo	seeds	840	2333	2800	1991	7422	7533	10314	8423
	seedlings	875	2654	3069	2199	5934	9453	13991	9793
	mean	858	2494	2935	2095	6678	8493	12153	9108
Mean yield	seeds	2269	3283	4804	3452	11188	11803	15069	12686
	seedlings	3826	5189	5368	4794	10667	15541	18713	14974
	mean	3048	4236	5086	-	10927	13672	16891	-
Total mean yield		4123				13830			

Table 2
MACRO- AND MICRONUTRIENT CONTENT OF FRESH PODS

Variety	Lady Di		Desiree		Polestar		White Apollo	
	¼ L _{max}	L _{max}						
Vegetation stage								
Moisture (g%)	92.90	92.96	92.97	91.31	93.68	93.00	91.13	91.39
Ash (g%)	0.60	0.65	0.60	0.72	0.66	0.63	0.76	0.73
Organic nitrogen (g%)	1.03	1.81	2.43	3.01	1.78	2.07	1.73	1.59
Proteins (g%)	6.43	11.31	15.18	18.81	11.12	12.93	10.81	9.93
Glucose (g%)	2.79	1.92	1.51	2.59	4.01	2.15	2.13	2.08
Ca (mg%)	45.10	33.76	11.90	46.56	24.22	33.99	40.20	58.58
Mg (mg%)	27.09	40.51	44.02	52.48	39.97	33.98	33.33	28.31
Fe (mg%)	0.54	0.43	0.23	0.46	0.45	0.51	0.45	0.49
Cu (mg%)	0.31	0.26	0.19	0.54	0.25	0.20	0.17	0.18

at ¼ of the maximum length varied between 11.90 mg% for Desiree and 45.10 mg% for Lady Di. For the fresh pods harvested at maximum length, the variation range was between 33.76 mg% for Lady Di and 58.58 mg% for White Apollo.

Magnesium concentration ranged between 27.09 mg% (Lady Di) and 44.02 mg% (Desiree) in freshly harvested samples of ¼ of the maximum length, respectively between 28.31mg% (White Apollo) and 52.48mg% (Desiree) on samples of fresh pods harvested at maximum length.

The iron concentration ranged from 0.23 mg% (Desiree) to 0.54 mg% (Lady Di) for fresh pods harvested at ¼ of the maximum length and from 0.43 mg% (Lady Di) to 0.51 mg% (Polestar) when the samples had maximum length. The spectrophotometric method applied for the determination of iron, the regression equation was $A = 0.0136C + 0.0048$ and $R^2 = 0.9946$.

Copper concentration varied between 0.1mg% in White Apollo and 0.31 mg% in Lady Di for pods at ¼ L_{max}, while for L_{max} pods it varied between 0.18 mg% for Polestar and 0.54 mg% for Desiree. The equation of the regression line of the spectrophotometric determination of copper was $A = 0.0331C + 0.0023$ with $R^2 = 0.9988$.

The concentration of vitamin C in frozen pods samples was determined using a spectrophotometric method within a 49 days period after freezing, because that method of conservation is equally relevant to both consumers and processors of vegetables [1]. The calibration line and the equation of the regression line are shown in figure 2.

Table 2 provides the results obtained, comparatively, for samples of fresh green beans harvested at ¼ of maximum

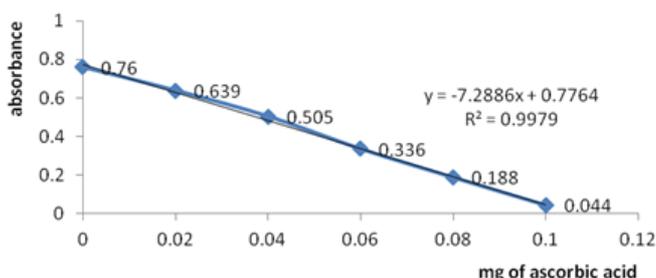


Fig. 2. Calibration curve for the determination of ascorbic acid

Sample	Variety	The length of the harvested pods	Percentage decrease of baseline (%)
1	Lady Di	¼ L _{max}	72.00
2		L _{max}	27.08
3	Desiree	¼ L _{max}	40.29
4		L _{max}	56.55
5	Polestar	¼ L _{max}	39.15
6		L _{max}	70.49
7	White Apollo	¼ L _{max}	31.81
8		L _{max}	39.71

length and at maximum length (L).

The first determination was performed 7 days after freezing, then the next two determinations were done 28 and 49 days after freezing. Evolution of ascorbic acid concentration during storage at -18°C of pods is shown in figure 3 and the percentage decrease of vitamin C concentration for each *Phaseolus coccineus* L. variety correlated with the notations in figure 3 is represented in table 3.

There is no data in the literature on the production of *Phaseolus coccineus* L. and no chemical compositional determinations; the vast majority of the data in the literature refer to the physico-chemical and sensory properties of *Phaseolus coccineus* L. seeds, most of the time compared to *Phaseolus vulgaris*. From this point of view, our study can be regarded as a starting point in extending the study of the runner beans.

In order to achieve a good correlation between our results and those published by other authors, we also performed the same determinations of chemical composition parameters for dehydrated pods, the results of which are shown in table 4.

The values obtained for protein concentration in dehydrated pods were comparable to those reported by other authors for *Phaseolus coccineus* L. seeds: $24.94 \pm 0.05\%$ and $27.56 \pm 0.07\%$ respectively [8]. From a nutritional point of view the intake of 100g of *Phaseolus coccineus* L. pods provides 4.60% Ca, 4.68% Mg and 3.97% Fe, out of the recommended daily intake for those minerals [27, 28].

Regarding the vitamin C intake, known for its antioxidant properties, it is obvious that fresh pods offer the maximum amount of ascorbic acid compared to the frozen or dry pods. The dynamic determination of ascorbic acid revealed the inverse proportionality between the duration of freezing and the amount of vitamin C preserved through that particular conservation method. There was a decrease of over 70% of the initial amount of vitamin C in the early pods with ¼ L_{max} of Lady Di and for and L_{max} pods for Polestar, while in Desiree and White Apollo varieties, the decrease in concentration of ascorbic acid was 40.29% (¼ L_{max} Desiree), 56.55% (L_{max} Desiree), 31.81% (White Apollo-¼ L_{max}) and 39.71% (White Apollo-L_{max}) respectively.

Table 3
PERCENTAGE DECREASE OF ASCORBIC ACID CONTENT AFTER FREEZING

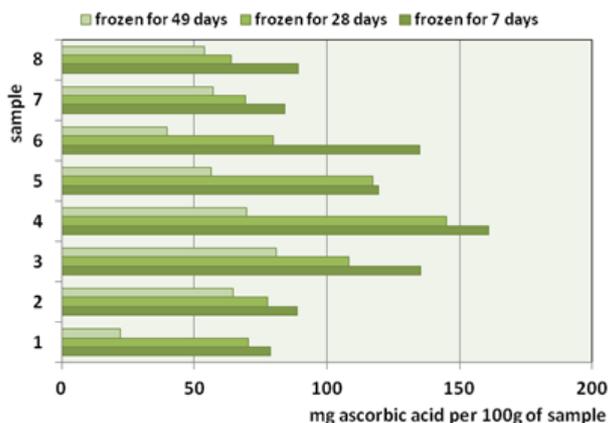


Fig. 3. Evolution of ascorbic acid concentration in the *Phaseolus coccineus* L. samples

Variety	Lady Di		Desiree		Polestar		White Apollo	
	$\frac{3}{4} L_{max}$	L_{max}						
Moisture (g%)	8.21	8.21	7.39	8.38	8.60	8.00	8.13	7.69
Ash (g%)	7.73	7.56	8.59	9.06	8.80	8.15	8.71	8.96
Organic nitrogen (g%)	2.21	2.36	2.91	3.24	2.83	2.61	2.77	3.35
Proteins (g%)	13.81	14.75	18.81	20.25	17.68	16.31	17.31	20.93
Ca (mg%)	351.95	403.83	261.90	327.92	234.47	294.14	284.50	414.76
Mg (mg%)	370.92	365.93	415.11	400.90	333.67	394.70	347.43	370.25
Fe (mg%)	3.80	1.61	1.50	3.36	1.52	4.45	3.46	6.70
Cu (mg%)	0.97	0.63	0.78	0.85	0.64	0.55	0.70	0.68

Table 4
MACRO- AND
MICRONUTRIENTS
CONTENT OF DEHYDRATED
PODS

These data support *Phaseolus coccineus* to be recommended as an important source of antioxidants among other vegetables [29] that should be taken into account as part of the medical nutrition therapy in conditions associated with high oxidative stress status [30].

Conclusions

The biological material, either seedling or seeds, used to set up the crop had a major influence on harvest time as the highest production values were recorded for crops obtained from seedlings as far as early production and total production.

The results obtained for the chemical composition parameters varied within narrow range in-between varieties and were consistent with the literature data when comparing the dehydrated pods with the fresh seeds of *Phaseolus coccineus* L. Also, the results obtained for each parameter were consistent for the two considered vegetation stages (maximum length and $\frac{3}{4} L_{max}$) and were comparable to the results reported in the literature.

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